

BETTIS

SERVICE INSTRUCTIONS

DISASSEMBLY AND REASSEMBLY

FOR MODELS

T3XX-SR-MX AND T4XX-SR-MX

SPRING RETURN

PNEUMATIC ACTUATORS

WITH A MANUAL HYDRAULIC

CONTROL PACKAGE

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1.0 **INTRODUCTION**

- 1.1 This service procedure is offered as a guide to enable general maintenance to be performed on Bettis models T3XX-SR(CW)-MX, T3XX-SR(CCW)-MX, T4XX-SR(CW)-MX and T4XX-SR(CCW)-MX Spring Return Series Pneumatic Actuators equipped with a Manual Hydraulic Override Package (includes actuator models that have a -10 or -11 suffix at the end of the model number).

NOTE: When the actuator model number has "-S" as a suffix then the actuator is special and may have some differences that are not included in this procedure.

1.2 **DEFINITIONS:**

WARNING: If not observed, user incurs a high risk of severe damage to actuator and/or fatal injury to personnel.

CAUTION: If not observed, user may incur damage to actuator and/or injury to personnel.

NOTE: Advisory and information comments provided to assist maintenance personnel to carry out maintenance procedures.

SR: Spring Cartridge

MX: Generically designates the Manual Hydraulic Override Package models M2, M7 or M11 as manufactured by Bettis Corporation.

- 1.3 **SAFETY STATEMENT:** Products supplied by Bettis, in its "as shipped" condition, are intrinsically safe if the instructions contained within this Service Instruction are strictly adhered to and executed by a trained, equipped, prepared and competent technician.

WARNING: **For the protection of personnel working on Bettis actuators, this procedure should be reviewed and implemented for safe disassembly and reassembly. Close attention should be noted to the WARNINGS, CAUTIONS and NOTES contained in this procedure.**

WARNING: **This procedure should not supersede or replace any customer's plant safety or work procedures. If a conflict arises between this procedure and the customer's procedures the differences should be resolved in writing between an authorized customers representative and a authorized Bettis representative.**

- 1.4 **BASIC SERVICE INFORMATION:** **Complete actuator refurbishment requires the actuator be dismantled from the valve or device it is operating.**

- 1.5 The maximum recommended service interval for this actuator series is five years. Storage time is counted as part of the service interval.

- 1.6 This procedure does not include M7 Manuel Hydraulic Control Package Disassembly and Reassembly Instruction. Bettis does not recommend periodic maintenance for the M7 itself. The M7 needs only to be serviced when it malfunctions. Complete M7 Package refurbishment should be done by Bettis.

NOTE: Do not remove the M7 Manuel Hydraulic Control Package and its piping until section 6 has been completed.

- 1.7 This procedure is applicable with the understanding that all electrical power and pneumatic pressure has been removed from the actuator, allowing the spring to stroke and rotate the actuator to its fail position. Also, it is understood that the actuator has been removed from the valve as well as all piping and accessories that are mounted on the actuator have been removed.

2.0 SUPPORT ITEMS AND TOOLS

- 2.1 Support Items - Bettis Service Kit, commercial leak testing solution, non-hardening thread sealant, and two each 7/8-9 UNC hex nuts.
- 2.2 Tools - All tools are American Standard inch. Large adjustable wrench, two (2) large screwdrivers, Allen wrench set, set of open/box-end wrenches, rubber or leather mallet, torque wrench (up to 5,000 inch pounds), breaker bar, 1/4" drift punch and a 1/2" drive socket set. For recommended tool list by item number refer to the last page of this procedure.

3.0 REFERENCE BETTIS MATERIALS

- 3.1 Assembly drawing part number 036144 for T3XX-SR(CW)-M7 actuator failing clockwise.
- 3.2 Assembly drawing part number 048102 for T4XX-SR(CCW)-M7 actuator failing counter clockwise.
- 3.3 Assembly drawing part number 035994 for T4XX-SR(CW)-M7 actuator failing clockwise.
- 3.4 Assembly drawing part number 048103 for T4XX-SR(CCW)-M7 actuator failing counter clockwise.
- 3.5 Exploded Detail drawing part number 063584 for T3XX-SRX-M7 actuators.
- 3.6 Exploded Detail drawing part number 063587 for T4XX-SRX-M7 actuators.

NOTE: Exploded Detail drawing is contained in Bettis standard Service Kit.

4.0 GENERAL DETAILS

- 4.1 This procedure should only be implemented by a technically competent technician who should take care to observe good workmanship practices.
- 4.2 Numbers in parentheses, () indicate the bubble number (reference number) used on Bettis Assembly drawing and Actuator parts lists.

- 4.3 This procedure is written using the following Actuator references:
- 4.3.1 Stop screw side of housing (1-10) will be considered the front of the actuator.
 - 4.3.2 Housing cover (1-20) will be the top of the actuator.
- 4.4 Mating parts should be marked for ease of reassembly, i.e. left and right stop screws and cylinder to housing.
- 4.5 When removing seals from seal grooves, use a small screwdriver with sharp corners rounded off or a commercial seal removing tool.
- 4.6 Use a non-hardening thread sealant on all pipe threads.

CAUTION: Apply the thread sealant per the manufacture's instructions.

- 4.7 Disassembly of actuator should be done in a clean area on a work bench.
- 4.8 LUBRICATION REQUIREMENTS: The actuator should be re-lubricated at the beginning of each service interval using the following recommended lubricant.

NOTES:

- 1. Lubricants, other than those listed in steps 4.8.1 should not be used without prior written approval of Bettis Product Engineering.
- 2. The following lubricant is for use in all areas of actuator except in the Manual Hydraulic Override Package (8) and hydraulic cylinder (4-10).

4.8.1 All Temperature Service (-50° F to +350° F) use Bettis ESL-5 lubricant. ESL-5 lubricant is contained in the Bettis Service Kit.

- 4.9 Fluid Requirements: For use in the M7 Manual Hydraulic Override Package (8) and the hydraulic cylinder (4-10).

NOTE: Fluids, other than those listed in steps 4.9.1, 4.9.2 and 4.9.3 should not be used without prior written approval of Bettis Product Engineering.

4.9.1 Standard Temperature service (-20°F to +200°F) use Dexron Automatic Transmission fluid.

4.9.2 High Temperature service (0°F to +350°F) use Dexron Automatic Transmission fluid.

4.9.3 Low Temperature service (-40°F to +150°F) use Exxon Univis J13 Hydraulic Fluid.

CAUTION: Pressure is not to exceed the maximum operating pressure rating listed on the name tag.

- 4.10 Before starting the general disassembly of the actuator, it is a good practice to operate the actuator with the pressure used by the customer to operate the actuator during normal operation. Notate and record any abnormal symptoms such as jerky or erratic operation. Also note if the actuators spring rotates back to the full fail position.
- 4.11 Some of the actuator models are very heavy and will require a means of assistance. For actuator approximate weight refer to following chart.

ACTUATOR MODEL (1)	APPROXIMATE WEIGHT (POUNDS) (2)				
	SR1	SR2	SR3	SR4	SR5
T310-SR-M7	571	491	420	427	430
T312-SR-M7	597	516	446	452	455
T316-SR-M7	645	564	494	500	N/A
T410-SR-M7	617	624	543	467	471
T412-SR-M7	649	655	575	499	502
T416-SR-M7	697	703	623	547	550
T420-SR-M7	770	776	696	620	N/A
NOTES: (1) Includes both fail clockwise (CW) and fail counter clockwise (CCW) actuator models. (2) Weights listed for each actuator model are for bare actuators without accessories or valve mounting brackets.					

5.0 GENERAL DISASSEMBLY

- 5.1 Make sure that the M7 package block/bypass valve, located on the right hand side of the control package, is fully open.
- 5.2 If not already removed, disconnect all operating pressure from actuator power cylinder (2-10), allowing the spring to stroke. The spring will rotate the yoke to the fail position.
- 5.3 Mark the stop screws (1-60) left and right. The setting of the stop screws (1-60) should be checked and setting recorded before stop screws are loosened or removed. NOTE: Stop screws will be removed later in this procedure.

6.0 SPRING CARTRIDGE REMOVAL

NOTE: Review all of Section 1 through Section 4 prior to the removal of the spring cartridge.

WARNING: Under no circumstances should the spring cartridge be cut open or apart, as the spring is pre-loaded and then the end caps and cylinder permanently attached around the spring with continuous welds.

CAUTION: Due to the weight and size of the spring cartridge (234 pounds), support equipment will be required when removing the spring cartridge from the actuator housing.

CAUTION: When spring cartridge is installed on the actuator the spring is under compression. Do not remove spring cartridge until actuator has "pre-load" removed.

- 6.1 SPRING CARTRIDGE "PRE-LOAD " REMOVAL - Use Method #1 steps 2 through 5 if the M11 package (8) is operational. Use Method #2 steps 6 through step 8 if the M11 package has been removed or is not operational.
- 6.2 **PRE-LOAD REMOVAL METHOD #1** - Close the block/by-pass valve located on the M11 package. Insert the pump handle into the pump handle holder and hand jack the pump until the actuator has moved a few degrees off of stop screw (1-60).
- 6.3 Locate the stop screw (1-60) that is on the opposite side of the housing from the spring cartridge (4-10) and loosen jam nut (1-120).
- 6.4 Unscrew the stop screw (1-60) until it runs into inner end cap (2-30).
- 6.5 Open the block/bypass valve on the M11 package and allow the spring to return the actuator to the spring extended position (fail position).
- 6.6 **PRE-LOAD REMOVAL METHOD #2** - Apply sufficient operating pressure to the pneumatic cylinder pressure inlet port, located in outer end cap (2-30), to move actuator yoke (1-160) off of stop screw (1-60).
- 6.7 Locate stop screw (1-60) that is on the opposite side of the housing from spring cartridge (4-10) and loosen jam nut (1-120).
- 6.8 Unscrew stop screw (1-60) until it runs into inner end cap (2-30).
- 6.9 Remove pressure from pressure inlet port and allow spring to return actuator to the spring extended position (fail position).
- 6.10 Remove socket cap screw (4-60), lockwasher (4-50), and nut retainer (4-40) between large hex nut on outboard end of the spring cartridge (4-10).

WARNING: Do not proceed to next step until spring cartridge "PRE-LOAD" has been removed.

- 6.11 Alternately loosen two large hex nuts on outboard end of spring cartridge (4-10). NOTE: The spring cartridge tie bar nuts are welded to the tie bars that extend through spring cartridge and screw into housing (1-10).

NOTE: To keep from inadvertently pulling tie bars back into spring cartridge use two each 7/8 inch by 9 UNC hex nuts and screw them onto the SR tie bars.

- 6.12 Unscrew tie bars until spring cartridge is free from the housing. Care should be taken so that tie bars are not pulled back into the spring cartridge. Place spring cartridge (4-10) to one side.

WARNING: Under no circumstances should the spring cartridge be cut open as the spring is pre-loaded and the spring cartridge welded around it.

7.0 TANDEM PNEUMATIC/HYDRAULIC CYLINDER DISASSEMBLY

- NOTES:
1. Review all of Section 1 through Section 4 prior to the disassembly of the Tandem Pneumatic/Hydraulic cylinder.
 2. If not already removed disconnect all operating pressure from the pneumatic power cylinder (2-10).
 3. Mark and record location of the pneumatic inlet ports on cylinder outer end cap (2-30) and inner end cap (2-40).

7.1 Remove snubber valve (1-190) from housing cover (1-20).

7.2 Remove breather assembly (4-30) from inner end cap (2-30).

7.3 Remove four socket cap screws (1-180) from position indicator (1-170)/yoke weather cover (3-130) and remove position indicator/yoke weather cover.

7.4 Drain the hydraulic fluid from Hydraulic Cylinder (2-40) by opening the bleed valves (2-240) and then removing the cylinder drain plugs (2-230). One is located on outboard end of hydraulic cylinder and the other on the inboard end of hydraulic cylinder.

NOTE: Actuator models manufactured after 1995 will not be provided with cylinder bleed plugs. Instead of one bleed plug and one pipe plug on each end of the cylinder there will be two pipe plugs on each end of the cylinder.

CAUTION: The bleed valves are 1/8 npt and are made out of brass. Use only the correct size wrench. Refer to tool list at the end of this procedure for recommended wrench style and correct wrench size. Do not use pliers or other style adjustable wrench for bleed valve removal or adjustment.

7.5 If the MX package is remote mounted then disregard the rest of this step. Remove the cylinder mounted MX Hydraulic Control package (8) from cylinder (2-40) by loosening the nuts/lockwashers on the mounting bracket u-bolts and then slid the MX/bracket assembly off of the end of cylinder (2-40).

CAUTION: Plug all ports in the MX package as foreign material may enter the system and cause the MX package to malfunction.

- 7.6 Remove socket cap screw (2-160), washer (2-150) and nut retainer (2-140).
- 7.7 Remove hex nuts (2-130) from tie bars (2-100).
- 7.8 Remove outer end cap (2-70). The fit between the hydraulic cylinder (2-40) and the outer end cap is very tight. Break the outer end cap free by tapping with a breaker bar on the lip provided on the end cap.
- 7.9 Pry inner end cap (2-60) away from outboard inner end cap (2-30). Break the inner end cap free from cylinder (2-40) by tapping with a breaker bar on the lip provided on the end cap.
- 7.10 Remove cylinder (2-40).
- NOTE: When sliding the cylinder off of piston (2-50), tilt cylinder (2-24) 15° to 30° degrees to the piston rod (2-170).
- NOTE: Keep split ring halves (2-110) in matched sets.
- 7.11 Remove ring retainer (2-120) and two split ring halves (2-110) from outboard side of piston (2-50).
- 7.12 Remove piston (2-50) from piston rod (2-170).
- NOTE: Keep split ring halves (2-110) in matched sets.
- 7.13 Remove ring retainer (2-120) and two split ring halves (2-110) from inboard side of piston (2-50).
- 7.14 Remove o-ring seals (5-60) from outboard end of tie bars (2-100).
- 7.15 Remove o-ring seal (5-40) from outboard end of piston rod (2-170).
- 7.16. Remove inner end cap (2-60) off tie bars (2-100) and piston rod (2-170).
- 7.17 Remove rod bushing (2-90) from outboard end cap (2-30).
- 7.18 Remove outboard end cap (2-30). The fit between cylinder (2-10) and end cap (2-30) is very tight. Break the end cap free by tapping with a breaker bar on the lip provided on the end cap.
- 7.19 Pry inboard end cap (2-30) away from housing (1-10). Break the inner end cap free from cylinder (2-10) by tapping with a breaker bar on the lip provided on the end cap.
- 7.20 Remove cylinder (2-10).
- NOTE: When sliding cylinder (2-10) off of piston (2-20), tilt the cylinder 15° to 30° degrees to piston rod (2-170).

NOTE: Keep split rings halves (2-110) in matched sets.

7.21 Remove ring retainer (2-120) and two split ring halves (2-110) from outboard side of piston (2-20).

7.22 Remove piston (2-20) from piston rod (2-170).

NOTE: Keep split rings halves (2-110) in matched sets.

7.23 Remove ring retainer (2-120) and two split ring halves (2-110) from inboard side of piston (2-20).

7.24 Remove o-ring seal (3-40) from piston rod (2-170).

7.25 Remove inner end cap (2-30) off over tie bars (2-100) and piston rod (2-170).

7.26 Remove rod bushing (2-80).

7.27 Unscrew tie bars (2-100) from housing (1-10). Flats are provided on the outboard end of the tie bars for wrench placement. DO NOT use a pipe wrench on the tie bars as it will mark the bar and cause seal leakage.

8.0 HOUSING DISASSEMBLY

NOTE: Review all of Section 1 through Section 4 prior to the disassembly of the housing.

8.1 Unscrew push rod (4-20) from yoke pin nut (1-30) and remove from housing.

8.2 Unscrew piston rod (2-170) from yoke pin nut (1-30) and remove. Flats are provided on the outboard end of the piston rod for wrench placement. DO NOT use a pipe wrench on the piston rod as it will mark the rod and cause seal leakage.

8.3 Remove housing cover screws (1-90) and gasket seals (3-100).

NOTE: The housing cover (1-20) will have a very tight fit.

8.4 Remove housing cover (1-20).

NOTE: It is not necessary to remove the four cover pins (1-130) from the cover (1-20).

8.5 Remove upper two yoke pin rollers (1-50) from the top of yoke pin (1-40).

8.6 Remove yoke pin (1-40) from yoke (1-160) and yoke pin nut (1-30).

8.7 Remove yoke pin nut (1-30).

8.8 Remove lower two yoke pin rollers (1-50) from housing (1-10).

8.9 Remove yoke (1-160) by lifting it from housing (1-10).

CAUTION: The yoke/housing bearing area must be lubricated and inspected to extend service life and prevent degradation of torque output. This can only be accomplished by removing the yoke from the housing which requires removing the actuator from the valve.

8.10 Remove stop screws (1-60), jam nuts (1-120), and seal gaskets (3-110). Be sure to mark or identify both stop screws as instructed in section 5.

8.11 It is not necessary to remove pipe plug (1-80) to service the actuator.

9.0 GENERAL REASSEMBLY

CAUTION: Only new seals that are still within the seal's expectant shelf life should be install back into actuator being refurbished.

9.1 Remove and discard all seals and gaskets.

9.2 All parts should be cleaned to remove all dirt and other foreign material prior to inspection.

9.3 Actuator Parts Inspection: Attention should be directed to threads, sealing surfaces and areas that will be subjected to sliding or rotating motion.

9.3.1 All parts should be thoroughly inspected for excessive wear, stress cracking, galling and pitting.

9.3.2 All sealing surfaces of the cylinder, tie bars and piston rod must be free of deep scratches, pitting, corrosion and blistering or flaking coating.

CAUTION: Actuator parts that reflect any of the above listed characteristics must be replaced with new parts.

9.4 INSTALLATION LUBRICATION INSTRUCTIONS:

NOTE: The parts and seals used in the actuator housing assembly and pneumatic power cylinder (2-10) will be assembled using lubricant as identified in "General Details" section steps 4.9.1 and 4.9.2. Parts and seals used in hydraulic cylinder (2-40) will be assembled using the hydraulic fluid identified in "General Details" steps 4.10.1 and 4.10.2.

9.4.1 Before installation coat all moving parts with lubricant.

9.4.2 Coat all seals with lubricant, before installing into grooves, also both sides of gaskets.

10.0 HOUSING REASSEMBLY

NOTE: Review all of Section 1 through Section 4 prior to the assembly of the housing.

- 10.1 If removed install drain plug (1-80) in actuator housing (1-10).
- 10.2 Inside housing (1-10) apply lubricant to the track and yoke bore.
- 10.3 Coat one of the o-ring seal (3-50) with lubricant and install into housing (1-10).
- 10.4 Apply lubricant to the slots in the upper/lower arms and the lower bearing surface of yoke (1-160).
- 10.5 Install yoke (1-160) into housing (1-10) as follows:
 - 10.5.1 Rotate yoke arms to approximately a 45° degree position in either direction and lower into the housing. NOTE: The yoke hub with tapped holes faces up.
 - 10.5.2 Rotate the yoke arms back to approximately mid-stroke (center) position.
- 10.6 Apply lubricant to the surfaces of all four yoke pin rollers (1-50).
- 10.7 Place one yoke pin roller (1-50) in the track in the bottom of the housing and position it under the slot in the yoke arms.
- 10.8 Place a second yoke pin roller on top of the first yoke pin roller in the slot in the lower yoke arm and align the holes in the yoke pin rollers.
- 10.9 Coat the upper and lower surfaces of yoke pin nut (1-30) with lubricant and insert into position between the yoke arms and parallel to the track in the housing. Align the yoke pin hole with the hole in the yoke pin rollers.
- 10.10 Lubricate the yoke pin (1-40) and insert through the yoke pin nut (1-30) and the two yoke pin rollers (1-50).
- 10.11 Install the third yoke pin roller over the yoke pin in the slot in the upper yoke arm and now install the fourth and last remaining yoke pin roller on top of the yoke pin roller you just installed in the upper yoke arm slot. The top roller will remain partially above the yoke and will engage the housing cover track when housing cover is installed.
- 10.12 Apply lubricant to piston rod (2-170) and rod bushing (2-80). Install rod bushing over the piston rod. NOTE: A new rod bushing is provided in the standard Bettis Service Kit.
- 10.13 Install piston rod (2-170) with rod bushing (2-80) into right side of housing for fail clockwise (CW) actuators. Slide rod bushing along the piston rod and into housing counter bore. Screw piston rod into yoke pin nut (1-30). NOTE: Do not torque tighten piston rod until the housing cover is installed later in this procedure.

10.14 Install push rod (4-20) into other side of housing (1-10) and screw into yoke pin nut (1-30).

NOTE: When installing push rod do not tighten until housing cover (1-20) has been installed.

10.15 Place jam nuts (1-120) and new gaskets (3-110) on stop screws (1-60).

10.16 Install the pre-assembled stop screws (1-60) into housing (1-10).

10.17 Place housing cover gasket (3-20) onto housing (1-10).

10.18 Coat remaining o-ring seal (3-50) with lubricant and install into housing cover (1-20).

10.19 Apply lubricant to the yoke bore and the track in housing cover (1-20).

10.20 Apply lubricant to upper bearing surface of yoke (1-160).

10.21 Install housing cover (1-20), being careful not to damage gasket (3-20) or yoke o-ring (3-50).

10.22 Install new seal gaskets (3-100) onto hex cap screws (1-90).

10.23 Install housing cover screws (1-90), with new seal gaskets (3-100), into housing cover.

NOTE: Leave housing cover screws loose, do not tighten.

10.24 Do this step only if you have pulled cover pins (1-130) or if you are replacing the cover pins.

NOTE: The cover pins (1-130) are grooved at one end, tapering to a smooth diameter at the other end.

10.24.1 Install four cover pins smooth end first into housing cover (1-20).

10.24.2 Drive four cover pins (1-130) through housing cover (1-20) and into housing (1-10) until each pin is flush with the housing cover.

10.25 Tighten housing cover screws (1-90).

10.26 TIGHTEN PISTON ROD AND PUSH ROD AS FOLLOWS:

10.26.1 Torque tighten piston rod (2-170) to 150 ± 7 foot pounds lubricated. NOTE: Flats are provided on the outboard end of the piston rod for wrenching purposes.

10.26.2 Tighten push rod, with a strap wrench, until tight.

10.27 Rotate yoke to a position that will leave a minimum of piston rod (2-170) protruding from actuator housing.

11.0 TANDEM PRESSURE/HYDRAULIC CYLINDER REASSEMBLY

- 11.1 Coat rod seal (3-70) with lubricant and install, lip first, into the recess provided in the inner end cap.

CAUTION: Install rod seal (3-70) with the energizer ring facing outboard side (away from housing).

- 11.2 Install end cap gasket (3-10) over piston rod (2-170) and rod bushing (2-80).

- 11.3 Install inner end cap (2-30) over piston rod (2-170) and rod bushing (2-80) and up against the housing. Install inner end cap with the large raised boss toward the housing (flat side outward).

NOTE: The inner end cap pressure inlet port should be toward the top of the actuator. Exercise extreme care during installation, in order to prevent damage to rod seal (3-70).

- 11.4 Apply lubricant to o-ring seal (3-60) and install into outer diameter seal groove on inner end cap (2-30).

- 11.5 Rod T-seal set (3-80) installation as follows:

NOTE: The rod Tseal is composed of one rubber seal and two split skive-cut back-up rings.

- 11.5.1 Apply lubricant to two sets of rod T-seal components (3-80).

- 11.5.2 Install the rod T-seals into piston (2-20) internal seal grooves.

NOTE: When installing the back-up rings, do not align the skive-cuts.

- 11.5.3 Install a back-up ring on each side of the rod T-seal.

- 11.6 Apply lubricant to o-ring (3-40) and place onto piston rod (2-170).

- 11.7 Install two matched halves of split ring (2-110) into the inner most groove in the piston rod and retain with one spiral retaining rings (2-120).

NOTE: Ribbed sections of piston (2-20) will face away from housing.

- 11.8 Install piston (2-20) onto the piston rod against split ring (2-210).

- 11.9 Install two matched halves of remaining split ring (2-110) onto the piston rod and retain with retaining ring (2-120).

NOTE: The original seal used in the outer diameter seal groove of piston (2-20) was a piston T-seal with two back-up rings. The replacement seal for this location is a Bettis D-ring seal (no back-up rings are required). The D-ring seal is directly interchangeable with the T-seal.

11.10 Coat D-ring seal (3-90) with lubricant and install on piston (2-20).

11.11 Take housing end of tie bars (2-100), end without wrench flat, and install by carefully pushing the tie bars through piston (2-20).

NOTE: Do not insert tie bars into inner end cap at this time.

11.12 Coat two o-ring seals (3-30) with lubricant and install onto the inboard end of tie bars (2-100) in the o-ring grooves provided.

11.13 Insert tie bars (2-100) through inner end cap (2-30) and screw into housing (1-10).

CAUTION: Tighten the tie bars until the threads bottom out, then back out each tie bar one-half (1/2) turn.

11.14 Apply lubricant to the bore of cylinder (2-10).

CAUTION: If needed when installing cylinder (2-10), hammer on end of cylinder only with a non metallic object.

11.15 Install lubricated cylinder (2-10) over piston (2-20) and onto inner end cap (2-30).

11.16 Apply lubricant to two o-ring seals (3-30) and install onto the second set of o-ring grooves provided on the tie bars.

11.17 Apply lubricant to o-ring seal (3-60) and install onto the second inner end cap (2-30).

11.18 Install the second inner end cap (2-30) onto the tie bars and into the end of cylinder (2-10).

NOTE: Pressure inlet port is to be located above actuator centerline.

11.19 Coat rod seal (5-70) with lubricant and install, lip first, into recess provided in the inner end cap.

CAUTION: Install rod seal (5-70) with the energizer ring facing outboard side (away from housing).

11.20 Apply lubricant to rod bushing (2-90), install it over piston rod (2-170) and slide it up into end cap (2-30).

11.21 Coat second rod seal (5-70) with fluid and install, lip first, into the recess provided in inner end cap (2-60).

CAUTION: Install rod seal (5-70) with the energizer ring facing outboard side (away from housing).

11.22 Install end cap gasket (101) over piston rod (2-170), rod bushing (2-90) and up against end cap (2-30).

- 11.23 Coat two o-ring seals (5-60) with fluid and install onto the inboard end of tie bars (2-100) in the o-ring grooves provided. NOTE: Due to "tandem" cylinder design, this will be the third set of o-ring grooves on the tie bars.
- 11.24 Install inner end cap (2-60) over piston rod (2-170) and rod bushing (2-90). Install with the counterbore facing the rod bushing (2-90). NOTE: The end cap pressure inlet port should be toward stop screw side of actuator.

CAUTION: Exercise extreme care during installation, in order to prevent damage to rod seal (5-70).

- 11.25 Apply fluid to o-ring seal (5-30) and install on inner end cap (2-60).

- 11.26 Rod T-seal set (3-80) installation as follows:

NOTE: The rod Tseal is composed of one rubber seal and two split skive-cut back-up rings.

- 11.26.1 Apply lubricant to two sets of rod T-seal components (3-80).

NOTE: When installing the back-up rings, do not align the skive-cuts.

- 11.26.2 Install the rod T-seals into piston (2-50) internal seal grooves.

- 11.26.3 Install a back-up ring on each side of the rod T-seal.

- 11.27 Apply fluid to o-ring (5-40) and place onto piston rod (2-170).

- 11.28 Coat the ends (second set of split ring grooves) of piston rod (2-170) with fluid.

- 11.29 Install two matched halves of split ring (2-110) into the inner most groove in the piston rod and retain with one spiral retaining rings (2-120).

- 11.30 Install piston (2-50) onto piston rod (2-170) and up against split rings (2-110).

- 11.31 Install two matched halves of the remaining split ring (2-110) onto the piston rod and retain with retaining ring (2-120).

- 11.32 T-seal set (5-90) installation as follows:

NOTE: The T-seal is composed of one rubber seal and two split skive-cut back-up rings.

- 11.32.1 Apply lubricant to two sets of T-seal components (5-90).

- 11.32.2 Install the T-seal into outer diameter seal groove of piston (2-50).

NOTE: When installing the back-up rings, do not align the skive-cuts.

- 11.32.3 Install a back-up ring on each side of the T-seal.

11.33 Apply fluid to the entire bore of cylinder (2-40).

CAUTION: If needed when installing cylinder (2-40), hammer on end of cylinder only with a non metallic object.

CAUTION: Make certain the back-up rings, components of the piston seal, are seated into the piston external seal groove. Should the back-up rings or seal member be pinched between the piston and cylinder, the components could be damaged, becoming a potential source of leakage.

11.34 Install end of cylinder (2-40) over piston (2-50) and onto inner end cap (2-60) - align pipe plug holes vertically or in the highest and lowest position when installed on the device the actuator is to operate. When installing the cylinder over the piston seal tilt cylinder 15° to 30° degrees to piston rod.

11.35 Apply fluid to two o-ring seals (5-60) and install onto the outboard end of tie bars (2-100) in the o-ring grooves provided.

11.36 Apply fluid to o-ring seal (5-30) and install onto outer end cap (2-70).

11.37 Install outer end cap (2-70) onto the tie bars and into the end of the cylinder (2-40). NOTE: Pressure port is to be facing stop screw side of housing.

11.38 Install two hex nuts (2-130) onto tie bars (2-60), using them to draw all of the cylinder components into position.

CAUTION: While the hex nuts (2-130) are being tightened, do not allow tie bars to rotate.

11.39 Alternately torque hex nuts (2-130) until a final torque of 65 ±7 foot pounds lubricated has been achieved.

11.40 Install nut retainer (2-140), securing in place with retainer screw (2-160) and lockwasher (2-150). It is necessary that the flats on hex nuts (2-130) be aligned and parallel before the nut retainer can be installed.

11.41 Install four pipe plugs (2-230) into hydraulic cylinder.

12.0 SPRING CARTRIDGE REINSTALLATION

NOTE: Make sure that the stop screws (1-60) have not been screwed into the point that 'Preload' will be created on the spring cartridge.

12.1 Install end cap gasket (3-10).

12.2 By pushing on the exposed push rod (4-20) or tapping it with a soft mallet, stroke the unit until the yoke touches the body at the end adjacent to the installed pressure cylinder.

12.3 Remove the safety nuts from the spring return cartridge (4-10).

- 12.4 Engage the spring return cartridge onto the push rod (4-20) and engage the tie bars by threading them into housing (1-10).
- 12.5 Torque tighten the tie bars to 65 ±7 foot pounds.
- 12.6 Install nut retainer (4-40), securing in place with the retainer screw (4-60) and lockwasher (4-50). NOTE: It is necessary that the flats on the hex nuts be aligned and parallel before the nut retainer can be installed.
- 12.7 Rotate yoke to full clockwise (CW) position (as shown on the clockwise assembly drawing).
- 12.8 Position yoke weather cover (3-130) and position indicator (1-170) on the yoke. Position indicator pointer will be facing the front of actuator and perpendicular to piston rod (2-170).
- 12.9 Secure position indicator (1-170) and weather cover (3-130) with socket head cap screws (1-180).

13.0 **ACTUATOR TESTING**

- 13.1 General Leak Testing:
 - 12.1.1 A small amount of leakage may be tolerated.
 - 12.1.2 Generally, a small leak testing bubble, which breaks about three seconds after starting to form, is considered acceptable.
- 13.2 All areas, where leakage to atmosphere may occur, are to be checked using a commercial leak testing solution.

WARNING: Pressure is not to exceed the maximum operating pressure rating listed on the name tag.

- 13.3 Unless otherwise listed all leak testing will use the nominal operating pressure (NOP) as listed on the actuator name tag or the pressure used by the customer to operate actuator during normal operation.

CAUTION: Test the actuator using a properly adjusted self relieving regulator, with gauge.

- 13.4 Before testing for leaks, alternately apply and release pressure, as defined in step 13.3, to the pressure side of the piston to stroke the actuator fully. Repeat this cycle approximately five times. This will allow the new seals to seek their service condition.
- 13.5 Apply pressure, as defined in step 13.3, to pressure inlet port located in pneumatic cylinder outboard end cap (2-30).

- 13.6 Apply a leak testing solution to the following areas:
 - 13.6.1 The breather port in the pneumatic cylinder inboard end cap (2-30), checks piston to cylinder and piston to piston rod seals.
 - 13.6.2 Joint between the outboard pneumatic cylinder end cap (2-30) and the cylinder (2-10). Checks cylinder to end cap o-ring seals.
 - 13.6.3 Joint between the outboard pneumatic cylinder end cap (2-30) and the hydraulic cylinder inner end cap (2-60). Checks pneumatic cylinder end cap to hydraulic cylinder end cap rod seals.
 - 13.6.4 The pressure port in hydraulic cylinder inner end cap (2-60). Checks the piston rod seal (3-70) and end cap o-ring seal (3-30).
- 13.7 Remove the pressure from the inlet port in the outboard pneumatic cylinder end cap (2-30).
- 13.8 Adjust the pressure regulator to 20 psig and apply to the pressure inlet port in the hydraulic cylinder inner end cap (2-60).
- 13.9 Apply a leak testing solution to the following areas:
 - 13.9.1 Apply a leak testing solution to the joint between the inner end cap (2-60) and the cylinder (2-40). Checks cylinder to end cap o-ring seals.
 - 13.9.2 Joint between the outboard pneumatic cylinder end cap (2-30) and the hydraulic cylinder inner end cap (2-60). Checks pneumatic cylinder end cap to hydraulic cylinder end cap rod seals.
 - 13.9.3 The pressure inlet port in the pneumatic cylinder outboard end cap (2-30). Checks the piston rod seal (5-70) and end cap o-ring seal (5-30).
 - 13.9.4 The pressure inlet port in the hydraulic cylinder outer end cap (2-70), checks piston to cylinder and piston to piston rod seals.
- 13.10 Remove the pressure from the inlet port in the hydraulic cylinder inner end cap (2-60).
- 13.11 If an actuator was disassembled and repaired, the above leakage test must be performed again.
- 13.12 Operation test the actuator to verify proper function of the actuator. This test is to be done off of the valve.
 - 13.12.1 Adjust the pressure regulator to the name tag NOP pressure.
 - 13.12.2 Apply the above pressure to the actuator power cylinder pressure inlet port and allow the actuator to stabilize. The actuator should stroke a full 90° degree travel.

- 13.13 Any jumpy or jerky operation, not attributed to seal drag or limited flow capacity, must be corrected and the above test performed again.
- 13.14 Remove NOP pressure from the pressure inlet port.

14.0 MX MANUAL HYDRAULIC OVERRIDE PACKAGE INSTALLATION

- 14.1 MX Manual Hydraulic Override Package Configurations:
 - 14.3.1 Actuators manufactured prior to April 30, 1975 will not be an integrated Uni-directional M7 and section 14 will not be applicable (Contact Service Coordinator Bettis Corporation, Waller Texas for information concerning this Manual Hydraulic Override Package).
 - 14.3.2 Actuators manufactured after April 30, 1975 will have an integrated Uni.-directional M7 Manual Hydraulic Override Package or one of its revisions and this procedure will be applicable to all M7 Manual Hydraulic Override Packages.
 - 14.3.3 Actuators field retrofitted or manufactured utilizing a Manual Hydraulic Override Package with a model designation of M11 (without a "-S") and section 14 will not be applicable. Use Bettis Service Procedure Part Number 126858 for instructions for operation and installation.

CAUTION: The unit must be mounted with reservoir upright (vertical).

CAUTION: Do not use Teflon tape to seal hydraulic system threads. Bettis recommend that a non hardening thread sealant, compatible with petroleum base hydraulic fluid be used in all MX Manual Hydraulic Control Systems.

- 14.2 If the M7 Control Package is not remote mounted then re-install the M7 package (8) on the hydraulic cylinder (4-10).
- 14.3 Reconnect all plumbing between the M7 package (8) and both inboard and outboard of the hydraulic cylinder.
- 14.4 Refilling of the M7 system and actuator cylinder is best accomplished using a pressure pump. If a pressure pump is not available go to step 14.5 for the manual field service refilling procedure.
 - 14.5.1 Allow the actuator to fully stroke to its fail position.
 - 14.5.2 Remove the breather from the top of M7 package reservoir.
 - 14.5.3 Attach the pump discharge line to reservoir breather port.
 - 14.5.4 Remove two pipe plugs (2-230) located at each end and on top of the hydraulic cylinder.

- 14.5.5 Open the M7 package block/by-pass valve.
 - 14.5.6 Slowly pump hydraulic fluid into the reservoir.. Approximately 3 to 5 psi will be required. As the fluid passes through the M7 package into the cylinder, air will be displaced.
 - 14.5.7 When fluid appears install pipe plug (2-230) into the hydraulic cylinders outboard port.
 - 14.5.8 Remove the pressure pump.
 - 14.5.9 With the actuator in its "fail" position; add fluid to the reservoir so that its level is within approximately 1-1/2 inches of full.
 - 14.5.10 Install the breather into the top of the M7 package reservoir.
- 14.5 Refilling the M7 package during field service often must be done without the use of a pressure pump. Proceed as follows:
- 14.5.1 Remove the breather from the top of M7 package reservoir.
 - 14.5.2 On hydraulic cylinder on which M7 package is mounted, the piston must be stroked toward outboard side of the actuator (actuator natural position for spring return actuators).
 - 14.5.3 Fill hydraulic cylinder with fluid by removing both pipe plugs (2-230) located at the top of hydraulic cylinder. After filling the hydraulic cylinder install the pipe plugs (2-230) back into the ports.
 - 14.5.4 Fill the M7 package reservoir. Maintain at least 1-1/2 inches of fluid within the reservoir at all times.
 - 14.5.5 Close the M7 package by-pass valve.
 - 14.5.6 Close both M7 package speed control valves.
 - 14.5.7 Remove pipe plug (2-230) located at outboard end and on top of the hydraulic cylinder.
 - 14.5.8 Operate M7 package hand pump slowly. Keep handle up for about 4 to 5 seconds before each pressure stroke. This allows time for the M7 package pump cylinder to fill in order that full displacement of the pump is utilized. NOTE: If the pump fails to deliver fluid, open the M7 package by-pass valve, rapidly operate the pump 15 to 20 times, close the M7 package by-pass valve and continue filling sequence.
 - 14.5.9 When fluid appears install pipe plug (2-230), removed in step 14.5.7, into the cylinders outboard port.

- 14.5.10 Remove pipe plug (2-230) located at inboard end and on top of the hydraulic cylinder.
- 14.5.11 Operate the M7 package hand pump to fully stroke the actuator. Refill M7 package reservoir as required.
- 14.5.12 Open M7 package by-pass valve.
- 14.5.13 Slightly open the M7 package outboard cylinder (right hand) speed control. As the actuator strokes, hydraulic fluid will be displaced from the greater volume of the outboard cylinder into the lesser volume of the inboard cylinder. Hydraulic fluid will begin flowing from the inboard end and on top cylinder port.
- 14.5.14 When hydraulic fluid appears install pipe plug (2-230), removed in step 14.5.10, into the cylinders inboard port. NOTE: If the actuator completes its stroke and fluid does not appear at the inboard port hole, omit procedure step 14.5.13 and proceed as follows:
- 14.5.15 Close the M7 package outboard cylinder (right hand) speed control valve.
- 14.5.16 Close the M7 package by-pass valve.
- 14.5.17 Remove pipe plug (2-230) located at inboard end and on top of the hydraulic cylinder.
- 14.5.18 Operate M7 package hand pump as described to cycle actuator.
- 14.5.19 When fluid appears install pipe plug (2-230), removed in step 14.5.17 into the cylinders inboard port. Stop operation of M7 package pump. NOTE: If fluid does not appear, repeat steps 14.5.8 through 14.5.13.
- 14.5.20 Open M7 package by-pass valve. Fully open M7 package inboard cylinder speed control.
- 14.5.21 Slowly open M7 package outboard speed control.
- 14.5.22 Allow the actuator to complete its stroke to "fail" position. Add fluid to reservoir so that level is within approximately 1-1/2 inches of full.
- 14.5.23 Install breather, removed in step 14.5.1, into top of M7 package reservoir.

WARNING: Pressure is not to exceed the maximum operating pressure rating listed on the name tag.

- 14.5.24 Connect pneumatic supply lines and cycle the actuator using available power media. Adjust and lock speed controls. Actuator is in normal service.

14.6 POWER OPERATION CHECK.

14.6.1 Fully open the M7 package block/by-pass valve, located on the right hand side of the M7 package.

14.6.2 Apply NOP pressure to the power cylinder and cycle the actuator. The actuator should be able to complete a full closed to open stroke in power operation.

14.6.3 Remove the pressure from the power cylinder and the actuator should complete an open to full closed position.

14.7 MANUAL OPERATION CHECK.

14.7.1 position or normal power Manual operation requires that the M7 package block/by-pass valve be fully closed.

14.7.2 Operate the M7 package hand pump until the actuator strokes from full clockwise (CW) to full counter-clockwise (CCW).

NOTE: When the actuator is fully stroked against the travel stops, an increased resistance in M7 package pumping effort will be noted. Continued operation of the M7 package pump simply circulates fluid through a high pressure relief.

14.7.3 Fully open the M7 package block/by-pass valve to reverse the actuator rotation or to return to the full closed operation position.

15.0 RETURN TO SERVICE

15.1 Install breather (4-30) in the inboard end cap (2-30).

15.2 Replace the software components of the snubber valve (1-190) and then install the snubber valve in the housing cover (1-20).

15.3 Adjust both stop screws (1-60) back to settings recorded in General Disassembly step 3.

15.4 Tighten both stop nuts (1-120) securely, while holding stop screw (1-60).

15.5 Actuator is ready to be returned to service.

15.6 After the actuator is installed on the valve all accessories should be hooked up and tested for proper operation and replaced if found defective.

T3 AND T4 TOOL STYLE AND WRENCH SIZES

ITEM NO.	WRENC H SIZE	T3 QTY	T4 QTY	LOCATION	RECOMMENDED WRENCH STYLE
1-60	1/2"	2	2	Stop Screw	Open End or Adjustable
1-80	9/16"	1	1	Housing Pipe Plug	Open End or Adjustable
1-90	1/2"	8	-	T3 Cover Screws	Socket
1-90	9/16"	-	8	T4 Cover Screws	Socket
1-120	1-5/16"	2	2	Stop Screw Nut	Box End (1)
1-180	3/16"	4	4	Weather Cover Screws	Allen
1-190	7/8"	1	1	Snubber Valve	Deep Socket
2-60	1/2"	2	2	Tie Bar Flats	Open End or Adjustable
2-90	1-7/16"	2	2	Tie Bar Nuts	Deep Socket
2-160	3/16"	1	1	Socket Cap Screw	Allen (1)
2-170	1-1/4"	1	1	Piston Rod Flats	Crows Foot (1)
----	1-7/16"	2	2	SR Tie Bar Nuts	Deep Socket
4-60	3/16"	1	1	Socket Cap Screw	Allen (1)
8	9/16"	4	4	M7 Mounting Package	Open End or Adjustable
(1) No alternate style tool recommended					

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NORTH & SOUTH AMERICA

19200 Northwest Freeway
Houston, TX 77065
USA
T +1 281 477 4100
F +1 281 477 2809

Av. Hollingsworth,
325, Iporanga Sorocaba
SP 18087-105
Brazil
T +55 15 3238 3788
F +55 15 3228 3300

ASIA PACIFIC

No. 9 Gul Road
#01-02 Singapore 629361
T +65 6501 4600
F +65 6268 0028

No.1 Lai Yuan Road
Wuqing Development Area
Tianjin 301700
P.R.China
T +86 22 8212 3300
F +86 22 8212 3308

MIDDLE EAST & AFRICA

P. O. Box 17033
Dubai
United Arab Emirates
T +971 4 811 8100
F +971 4 886 5465

P. O. Box 10305
Jubail 31961
Saudi Arabia
T +966 3 340 8650
F +966 3 340 8790

24 Angus Crescent
Longmeadow Business Estate
East P.O. Box 6908; Greenstone
1616 Modderfontein, Extension 5
South Africa
T +27 11 451 3700
F +27 11 451 3800

EUROPE

Berenyi u. 72- 100
Videoton Industry Park,
Building #230
Székesfehérvár 8000
Hungary
T +36 22 530 950
F +36 22 543 700

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